URadio: Towards Secure Smart Home IoT Communication Using Hybrid Ultrasonic-RF Radio
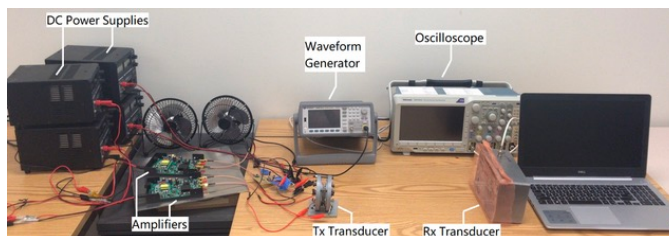
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Challenge in Smart Home IoT:

- Multiple wireless technologies coexist and compete for scarce spectrum resources
- RF communication can be easily eavesdropped by adversaries using cheap off-the-shelf equipment
- Sophisticated jamming attacks can stealthily and selectively drop packets or cause DoS
- Unauthorized devices may inject fraudulent requests to gain system access for data exfiltration
- How to efficiently authenticate smart home IoT devices and communications given the sheer amount of the devices to be managed in the near future?
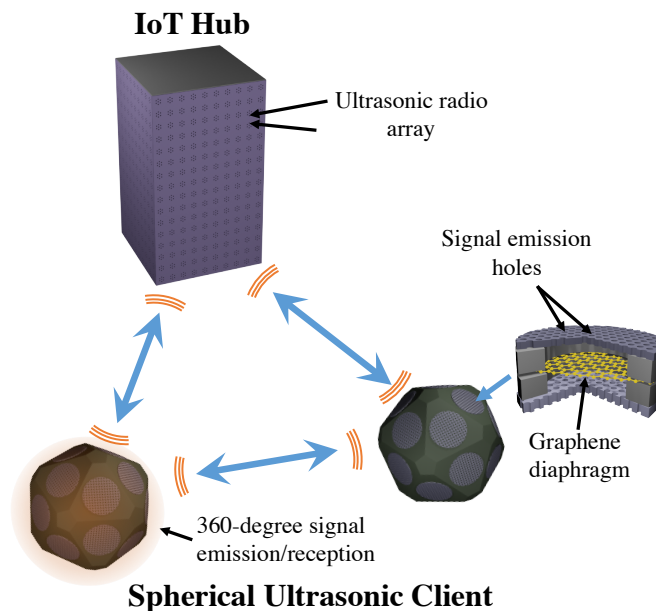
Solution:

- **Ultrasonic-RF transceiver**: design a hybrid ultrasound/radio-frequency transceiver using a wideband ultrasonic transducer to enable secure and reliable IoT communication using a wideband ultrasonic transducer by leveraging phased acoustic array technology
- **Anti-jamming communication**: Ensure the robustness of IoT communications by developing multiple-input multiple-output (MIMO) interference cancellation and directional ultrasonic anti-jamming communication technologies
- **Device authentication**: Design a location-restricted device authentication mechanism without the reliance on credentials by leveraging signal features of the ambient radio-frequency and ultrasonic signals

IoT Hub

Ultrasonic radio array

Signal emission holes

Graphene diaphragm

360-degree signal emission/reception

Spherical Ultrasonic Client

Scientific Impact:

- Results from this project will make a solid step towards advancing our understanding of security in smart home IoT networks, thereby providing guidance on the design of next-generation smart home systems.
- The research will result in a new communication system and various new security mechanisms that can provide secure and reliable IoT communication on two different types of spectrums, and will help address the crowded RF spectrum issue and prevent security attacks towards IoT devices such as Mirai and Brickerbot attacks
- The proposed solutions will be rigorously tested using large-scale simulations and experimentally tested via SDR testbeds and ultrasonic radio prototypes. Results from this project will lead to a new knowledge frontier for the design and implementation of secure and reliable IoT systems.

Broader Impact:

- The research conducted through this project will significantly improve the security of smart home networks to allow people to enjoy robust and trustworthy smart home services, and can be potentially extended to secure other IoT systems, including military, agriculture, healthcare, etc.
- The project has an emphasis on the practicality of the developed solutions, the PI works closely with IoT companies for possible technology transfer.
- Incorporate the knowledge developed in this project into both undergraduate and graduate course modules.
- Disseminate research finding to K-12 students in STEM disciplines through summer research program and seminars.